Consumer Acceptance of Cultured Meat: A Systematic Review

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Abstract

Cultured meat grown in-vitro from animal cells is being developed as a way of addressing many of the ethical and environmental concerns associated with conventional meat production. As commercialisation of this technology appears increasingly feasible, there is growing interest in the research on consumer acceptance of cultured meat. We present a systematic review of the peer-reviewed literature, and synthesize and analyse the findings of 14 empirical studies. We highlight demographic variations in consumer acceptance, factors influencing acceptance, common consumer objections, perceived benefits, and areas of uncertainty. We conclude by evaluating the most important objections and benefits to consumers, as well as highlighting areas for future research.

1. Introduction

The ethical and environmental concerns associated with meat production will be exacerbated as millions rising out of poverty in developing countries drive a 73% increase in demand for meat by 2050 (Food and Agriculture Organization, 2003, 2011). Meanwhile, consumers in the West are unwilling to reduce their meat consumption (Tobler, Visschers, & Siegrist, 2011), yet are increasingly concerned about the implications of meat for sustainability and animal welfare (Vinnari & Tapio, 2009). Alongside changes to conventional farming systems, various types of artificial meat may play a role in addressing these issues (Bonny, Gardner, Pethick, & Hocquette, 2017).

One proposed solution is cultured meat, which can be grown from animal cells in a culture medium rather than being taken from slaughtered animals (Post, 2012). Cultured meat largely circumvents the need for animals in the meat production system, alleviating a milieu of animal welfare, public health, and environmental concerns associated with conventional meat (Hopkins & Dacey, 2008; Mattick, Landis, & Allenby, 2015; Tuomisto & de Mattos, 2011; Zhi-Chang, Qun-Li, & Lin, 2015).

Several prototypical cultured meat products have been made (BBC, 2013; The Telegraph, 2017), and whilst it is not yet available commercially, several producers are aiming to sell cultured meat within five years (BBC, 2015; Business Insider UK, 2017). Given the expected commercialisation of the technology, and widespread consumer rejection of other conceptually similar food technologies such as GMOs (Bánáti, 2011), there is now significant interest in consumer acceptance of cultured meat. Some have claimed that consumer acceptance could be the biggest barrier cultured meat faces (Sharma, Thind, & Kaur, 2015).

Consumer acceptance of cultured meat has been the subject of several studies in recent years. Hartmann and Siegrist (2017) recently explored this as part of a systematic review. However, this review was restricted to quantitative studies, which meant valuable insights from several qualitative studies were omitted (O'Keefe, McLachlan, Gough, Mander, & Bows-Larkin, 2016; Verbeke, Marcu, et al., 2015). Moreover, several relevant studies have been published since that review, such is the present interest in cultured meat (including Siegrist & Sütterlin, 2017; Wilks & Phillips, 2017).

Given the increasing urgency of addressing sustainability in meat production and the impending commercial feasibility of cultured meat, it is imperative to synthesize the current evidence base about public perceptions of cultured meat. The present systematic review, therefore, aims to provide an updated and comprehensive answer to the question, 'What is known about consumer acceptance of cultured meat?' It is hoped that the findings will be of use to researchers looking at public understanding of novel food technologies, and those in the industry developing cultured meat.

2. Methodology

This systematic review sought to identify, collate, and synthesize the findings of empirical studies looking at consumer acceptance of cultured meat. The review followed the five steps outlined by Khan, Kunz, Kleijnen, and Antes (2003): framing the question, identifying relevant publications, assessing study quality, summarising the evidence, and interpreting the findings.

2.1. Framing the question

This review addressed the question: what is known about consumer acceptance of cultured meat? We applied the inclusion/exclusion criteria listed in Table 1.

<TABLE 1>

2.2 Identifying relevant publications

We searched a broad variety of literature databases using a search term[1] including a wide range of alternative terms for 'consumer acceptance' and 'cultured meat'. Figure 1 depicts how these records were subsequently filtered:

<FIGURE 1>

2.3 Assessing study quality

The 14 studies identified as relevant were then subject to a quality assessment using the Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields (Kmet, Lee, & Cook, 2004). Since all the eligible studies identified achieved reasonable quality ratings, none were excluded from the review. The quality assessment did, however, highlight methodological concerns in some studies, which led to caveats being issued in relation to their findings.

[1] Available from author.

3. Results

A summary of each included study's design, sample, description given of cultured meat, and main findings is shown in Table 2.

<TABLE 2>

These findings will be further discussed in four sections. First, we will review the overall picture of consumer acceptance, including survey data, demographic variations, and factors which may influence acceptance. Secondly, we will discuss common personal and societal objections to cultured meat. Thirdly, we will highlight some areas in which there is significant consumer uncertainty. Finally, we will discuss some of the perceived benefits of cultured meat.

3.1 Consumer acceptance

First, we will discuss findings which relate to overall willingness to eat cultured meat.

3.1.1 Personal willingness to eat cultured meat

Three surveys have investigated the rate of personal willingness to consume cultured meat, each with different findings (Hocquette et al., 2015; Slade, 2018; Wilks & Phillips, 2017). These differences are likely underpinned by differences in the samples, descriptions of cultured meat, and question design.

Wilks and Phillips (2017) give an overall positive view of consumer acceptance, reporting that 65.3% would be willing to try cultured meat, of whom 32.6% would be willing to eat it regularly, 47.7% would be more willing to eat it compared to soy-based meat substitutes, and 31.5% would be willing to eat it as a replacement for farmed meat. Hocquette et al. (2015), meanwhile, found that between 5 and 11% of their respondents said they would eat cultured meat, and Slade (2018) report that 11% chose cultured meat over conventional and plant-based alternatives.

Whilst Wilks and Phillips (2017) and Slade (2018) surveyed reasonably representative samples with minor deviations from census populations, Hocquette et al. (2015) did not intend their sample to be representative, thus limiting generalizability: 40.4% of their total sample were scientists, 9.3% were working in the meat sector, and a further 11.3% were

scientists working on meat, whilst some respondents were from ‘mailing lists or groups of people known by researchers’ (p. 275).

Furthermore, as shown in Table 2, the descriptions of cultured meat given to participants differed greatly. More importantly, respondents in each survey answered very different questions: Wilks and Phillips (2017) asked participants whether they would try, buy regularly, prefer to other products, and pay more for cultured meat, and participants used Likert scales to indicate their propensity to do each of these. Conversely, Slade (2018) used a hypothetical choice experiment, asking participants to choose between cultured meat burgers, plant-based burgers, and conventional burgers. Similarly, Hocquette et al. (2015) asked respondents to choose between eating cultured meat, reducing their meat consumption, becoming vegetarian, or changing nothing in their meat consumption. In practice these options are not mutually exclusive, and therefore the conclusion that ‘only a minority of respondents (from 5 to 11%) would recommend or accept to eat *in vitro* meat instead of meat produced from farm animals’ (p. 273) should be taken with some scepticism.

Overall, these studies indicate that most consumers are willing to try cultured meat, but a relatively small proportion would choose it over conventional meat or other meat alternatives. In practice, this preference is likely predicated on a number of factors such as taste, price, and popularity. Since cultured meat is not currently available commercially, these things cannot be accounted for.

Nonetheless, studies suggest some demographic variation in willingness to engage with cultured meat. Wilks and Phillips (2017) report that males (vs. females), liberals (vs. conservatives), and low income respondents (vs. high income respondents) were significantly more willing to try cultured meat. They also find that, whilst vegetarians and vegans had more positive perceptions of some aspects of cultured meat, they were significantly less willing to consume it than were omnivores. Slade (2018) provide further support for males having higher preference for cultured meat, and note the same preference amongst younger and more educated respondents. Some of these trends are also observed in the qualitative work of Tucker (2014) who reported that men, younger people, and city-dwellers showed more willingness to eat cultured meat compared to women, older people, and rural participants respectively. There is also some evidence of cultural variation in the way consumers relate to cultured meat (Bekker, Tobi, & Fischer, 2017), though this is based on non-generalizable qualitative work.

3.1.2 Factors influencing acceptance

Some evidence suggests that increased familiarity with cultured meat is associated with increased acceptance (Bekker, Fischer, Tobi, & van Trijp, 2017; Wilks & Phillips, 2017), though this has not been tested statistically. Verbeke, Marcu, et al. (2015) reported that participants were less resistant to the concept at the end of focus group discussions compared to the start. Indeed, such a relationship would be in line with what one would expect based on the mere exposure effect (Zajonc, 2001). Lack of familiarity may underpin many of the 'sense-making strategies' identified by Marcu et al. (2015, p. 11): these included using metaphors such as 'Frankenfoods' and 'zombies', as well as using commonplaces such as 'playing God' and 'interfering with nature' as bottom line arguments which closed off further debate. Anchoring cultured meat to more familiar technologies (such as GMOs and cloning) and attempting to define cultured meat in terms of its similarities and differences compared to conventional meat also indicated an attempt to locate the concept in a network of the familiar. Conversely, some participants engaged in pragmatic reasoning, weighing up the costs and benefits of cultured meat, reflecting on the process of public acculturation to new technologies, revealing dilemmas and ultimately expressing ambivalence.

Meanwhile, experimental data indicates that measures of acceptance are sensitive to information provision. Verbeke, Sans, and Van Loo (2015) found that self-reported willingness to try, purchase, and pay more for cultured meat increased when participants were given additional information about the benefits for the environment and public health, compared to when they just had basic information. Whilst this study is somewhat limited by the sample and before/after design, its findings are corroborated by Bekker, Fischer, et al. (2017), who report that positive or negative information about cultured meat changed explicit (but not implicit) attitudes towards cultured meat in the direction of the information. Subsequent experiments in this study found that providing positive/negative information about solar panels (a related product in the 'sustainability' category) also affected attitude measures towards cultured meat, leading the authors to speculate that 'The pre-activated associations with sustainability in turn may have facilitated making sense of the unfamiliar attitude object.' (p. 252). This interpretation of their results seems to be in line with Marcu et al.'s (2015) identification of anchoring to familiar technologies as a key part of the sense-making process surrounding cultured meat.

Additionally, Siegrist, Sütterlin, and Hartmann (2018) found a significantly higher rate of acceptance when participants were given a non-technical description of cultured meat compared to a technical description due to a difference in perceived naturalness and evoked disgust. The authors recommend that advocates give non-technical descriptions of cultured meat which focus on the similarity of the product to conventional meat, rather than the difference of the production process.

Finally, Slade (2018) found that preference for cultured meat was significantly higher when its price was lower, and when its perceived market share was higher. Whilst the former is in line with other research (see Section 3.2.1 on anticipated price), the latter indicates that perceived popularity is a predictor of acceptance; the author speculates that this could be due to a desire to conform to social norms, or because consumers use popularity to infer product quality. In any case, it must be considered that existing research has framed cultured meat as a future technology, unverified by other consumers, and therefore consumer acceptance in practice may differ significantly from the observations of these studies.

3.2 Common objections to cultured meat

Common objections to cultured meat broadly relate to either personal or societal concerns.

3.2.1 Personal concerns

Unnaturalness

Amongst the most common objections to cultured meat is that it is unnatural. Marcu et al. (2015) report that 'natural vs. artificial' is one of the polarities participants established in order to locate cultured meat relative to conventional meat. Indeed, participants in other studies have referred, unprompted, to 'real meat' (as opposed to cultured meat) in the context of these discussions (Tucker, 2014; Verbeke, Marcu, et al., 2015), or have described cultured meat as 'fake' (Bekker, Tobi, et al., 2017). Laestadius (2015) observed that, unlike other concerns, the unnaturalness objection has been recorded universally across a range of cultures.

As well as forming the basis for some claims that it may be dangerous to consume or cause environmental harm (Laestadius & Caldwell, 2015; Verbeke, Marcu, et al., 2015), perceived unnaturalness causes some to believe that cultured meat is inherently unethical (Laestadius,

2015). As Marcu et al. (2015, p. 9) argue, some deploy nature as an ideology within which anything natural is construed as being good/healthy, and anything unnatural is bad or carries risks. This ideology may have formed the ground for some to dismiss cultured meat using the commonplace 'interfering with nature' argument.

Laestadius (2015) provides an insightful analysis of the unnaturalness perception, arguing that ethical concerns stemming from the alleged unnaturalness of cultured meat fall into two categories: practical concerns about unknown consequences of the technology causing tangible harm to human health or the environment, and a more fundamental conceptualisation of unnaturalness as inherently unethical. She argues that the former could be addressed by further research or exposure over time, whilst the latter may be insensitive to evidence, and further cautions against dismissing such concerns as naturalistic fallacy, arguing that prevailing ethics have real world consequences regardless of whether they are, in themselves, sound.

Nonetheless, there is some evidence of people overcoming the unnaturalness objection. O'Keefe et al. (2016) found that participants considered that many other phenomena in modern society are unnatural, yet widely accepted, a finding mirrored by Verbeke, Marcu, et al. (2015). Laestadius (2015, p. 997) identified some comments arguing that conventional meat is also unnatural ('riddled with… hormones and bacteria', as one commenter said), though she notes that this argument did not necessarily extend to the conclusion that naturalness should not matter.

Quantitative studies highlight the role perceived unnaturalness plays in acceptance. Whilst Wilks and Phillips (2017) report overall agreement that cultured meat is unnatural compared to conventional meat, Siegrist and Sütterlin (2017) demonstrate experimentally that perceived naturalness mediated respondents' acceptance of health risks associated with conventional vs. cultured meat. Siegrist et al. (2018) also found perceived naturalness to mediate willingness to consume cultured meat, directly and indirectly via evoked disgust.

Other evidence supports the link between perceived naturalness and disgust: Verbeke, Marcu, et al. (2015) report that this was one of the first reactions observed, and was experienced as a shared emotion in focus groups. Some of their participants described cultured meat as 'vile', 'freakish' and 'weird' (p. 52). In their content analysis of online comments, Laestadius and Caldwell (2015) report that 10% of the commenters observed expressed disgust, and many

used terms like ‘lab-meat’ and ‘test-tube’ in a pejorative way. Although disgust is likely to be partly explicable through traditional notions that it guards against ingesting potentially harmful substances (Rozin & Fallon, 1987), Laestadius (2015) notes that some disgust was morally grounded.

Safety

A common related concern regarding cultured meat was food safety. Safety concerns were reported in many of these studies; Verbeke, Marcu, et al. (2015) report that this concern was linked to the perception of unnaturalness (mirroring the findings of Siegrist and Sütterlin (2017) and Siegrist et al. (2018)) and to a sense of scientific uncertainty. Laestadius and Caldwell (2015) report some concerns that cultured meat could be linked to cancer, for example. Hocquette (2016) explains that cancerous cells could develop through cell proliferation, but are unlikely to harm consumers as they are dead when digested. However, many studies also report some participants perceiving potential safety benefits; O'Keefe et al. (2016), in particular, highlight this in relation to BSE affecting conventional meat, and report that participants expressed confidence that cultured meat would not be allowed to be sold unless it was proven safe. Verbeke, Marcu, et al. (2015) also reported that participants perceived possible safety benefits, though they expressed concerns about regulation in this context.

On balance, there are more concerns than optimism expressed around the issue of safety in the qualitative literature. However, the quantitative data seems to tell a different story: Verbeke, Sans, et al. (2015) report that participants gave a mean rating slightly favouring ‘safe’ rather than ‘not safe’ on a 7-point scale, whilst Wilks and Phillips (2017) reported similarly favourable figures on a question about the risk of zoonoses from cultured compared to conventional meat. It seems that, whilst people discuss safety concerns in focus groups and online comments, when asked directly about this issue in surveys, overall results err towards a perception of safety. This may reflect the difference between perception of risk and acceptability of risk highlighted by the results of Siegrist and Sütterlin (2017): because the risk is perceived as coming from an unnatural source, it is worthy of more attention, though the level of risk itself may be low.

Healthiness

A further common concern observed in the literature relates to the nutritional content of cultured meat. Verbeke, Marcu, et al. (2015) report that participants generally thought that cultured meat would be less healthy than conventional meat, a concern also observed by Laestadius and Caldwell (2015). Both of these studies noted that some participants were open to perceiving health benefits relative to conventional meat, especially in relation to its lower fat content, although such perceptions were outnumbered by concerns about unhealthiness. Bekker, Tobi, et al. (2017) also observe mixed perceptions here, whilst Tucker (2014) notes that although some participants said cultured meat was likely to be unhealthy, this was not a key reason for rejection. Hocquette et al. (2015) found that 28.6% of their respondents thought that cultured meat would be healthy, whilst 37.9% thought it would not be (33.5% did not know). Both Verbeke, Sans, et al. (2015) and Wilks and Phillips (2017) reported mean figures almost exactly in the middle of the 'healthiness' scales included in their studies, indicating that there is overall uncertainty as to the healthiness of cultured meat.

Anticipated taste/texture/appearance

Many consumers anticipate cultured meat having an inferior taste, texture, or appearance compared to conventional meat. This is a major theme highlighted by Tucker (2014), who argues that lack of sensory appeal was the main reason underpinning rejection of cultured meat. Similarly, Verbeke, Marcu, et al. (2015) reported that many participants anticipated inferior taste, and those who said they might eat it said that tasting as good as conventional meat would be a condition of regular consumption. O'Keefe et al. (2016) highlighted some participants wanting to be able to compare cultured meat side-by-side with conventional meat for aesthetic appeal, whilst Bekker, Tobi, et al. (2017) find evidence of concerns about taste and texture (some anticipated a 'soft' or 'boring' texture) were held by participants from all three countries in their study. Laestadius and Caldwell (2015) found comments on online news articles anticipating a good and bad taste in equal measure; those who were pessimistic about the taste and texture often mentioned the lack of fat, which was mentioned in several of the news articles from which comments were gathered. Hocquette et al. (2015) found that just 23.6% of their respondents thought that cultured meat would be tasty; 39% thought it would not be, and 37.5% did not know. Wilks and Phillips (2017) and Verbeke, Sans, et al. (2015) both report that their samples, on average, thought that cultured meat would be less tasty than conventional meat, whilst Slade (2018) found that almost 90% of their sample believed

cultured meat would taste worse than conventional meat, though most thought it would taste better than plant-based meat alternatives.

Anticipated price

Bekker, Tobi, et al. (2017) report that price was a theme discussed by participants from all cultures; some participants anticipated cultured meat being cheaper whilst others thought it would be more expensive. Verbeke, Marcu, et al. (2015) also report such uncertainty, further noting that some participants said they would buy cultured meat if it was cheaper, whilst others thought the perceived ethical benefits would justify paying the same price. O'Keefe et al. (2016) report that their participants said it would have to be cheaper to achieve mainstream acceptance, but also discussed the possibility of producing superior cuts of meat at a cheaper price. Slade (2018) found that a lower price was a significant predictor of preference for cultured meat, indicating that price competitiveness will likely be important for consumers in practice. Laestadius and Caldwell (2015) note that many commenters reacted to the very high 'price' of around $350,000 reported in the media, which was in fact the cost of the entire research project. This sensationalist reporting may contribute to the perception that cultured meat is expensive.

Whilst Verbeke, Sans, et al. (2015) report that their participants anticipated a slightly higher price, Wilks and Phillips (2017) found that their participants, on average, expected it would be cheaper 'on a global level' to meet demand for meat using cultured rather than conventional meat. This discrepancy is likely due to framing; the phrasing of the latter question may have triggered the idea that cultured meat could be produced cheaply to feed the global poor. Indeed, the idea that cultured meat could be used to feed the global poor who cannot afford conventional meat is a common theme in the literature (Bekker, Tobi, et al., 2017; Tucker, 2014). Verbeke, Marcu, et al. (2015) note that this idea allowed some participants to accept cultured meat in principal, whilst rejecting it in practice. Laestadius (2015) reports that some commenters thought this was a good thing, whilst others perceived an injustice whereby only the rich would get 'real' meat.

3.2.2 Societal concerns

There is also evidence of societal concerns relating to the end of traditional animal agriculture, distrust of companies producing cultured meat, and the energy required for production.

Wilks and Phillips (2017) found that, overall, survey respondents agreed that cultured meat would have negative impacts on traditional farmers. Such concerns were mirrored by the participants of Bekker, Tobi, et al. (2017), whilst Verbeke, Marcu, et al. (2015) stress that the anticipated losses to farming were social and cultural as well as economic: participants also worried that cultured meat might take away from cultural rituals in which meat plays a central role, such as barbecues and Sunday roasts. Furthermore, they expressed regret about the possible erosion of the countryside, as well as the tradition and heritage of farming (see Fiddes, 1994). In general, the end of traditional farming was thought of as unwelcome.

Interestingly, Laestadius and Caldwell (2015) comment that these concerns seem less prominent amongst American consumers, perhaps because much of US agriculture is already industrialised (Laestadius, 2015). However, some did worry about the consolidation of power in the food system which could accompany a shift towards cultured meat production. Indeed, Laestadius and Caldwell (2015) report that 4% of commenters expressed such concerns, with one commenter claiming that the innovation was motivated by 'vast profits, or fame' (p. 2463). Similarly, Verbeke, Sans, et al. (2015) note that in the aftermath of debates about GMOs, consumers are likely to see such products as being 'driven by corporate interests' (p. 56).

Many consumers expressed concerns that in the future, they may be consuming cultured meat without their knowledge (Laestadius & Caldwell, 2015). O'Keefe et al. (2016) reported participants discussing maintaining food choice in this context, whilst Verbeke, Marcu, et al. (2015, p. 54) quote one participant as saying 'If they can get your money, I don't think you will never [sic] know what you will eat.' This perception led some consumers to demand that regulation should ensure transparency in cultured meat labelling, marketing, and information provision. Laestadius (2015) quotes one commenter who alluded to the idea that cultured meat would be 'slipped' into the diets of the poor, whilst the rich would continue to have access to conventional meat. Marcu et al. (2015) and Laestadius and Caldwell (2015) report some going further, alluding to dystopian sci-fi-like future visions involving Jurassic Park and Soylent Green. The latter observed some concerns that cultured meat could enable a future where cannibalism is acceptable (see Leroy & Praet, 2017).

Rather more practical societal concerns pertain to the amount of energy needed for cultured meat production. Verbeke, Marcu, et al. (2015) and Laestadius and Caldwell (2015) both

report this concern amongst consumers, although in general these concerns seem to be outweighed by perceptions that cultured meat will be relatively sustainable.

3.3 Doubts and uncertainty

Consumers express doubt and uncertainty regarding some aspects of cultured meat, in particular its feasibility, ethical status, and how it will be regulated.

3.3.1 Feasibility

Verbeke, Marcu, et al. (2015) and O'Keefe et al. (2016) both report some scepticism about the feasibility of cultured meat, although participants recognised that other food technologies were once thought to be unfeasible (including microwave meals and astronauts eating 'food in a tube'). Laestadius and Caldwell (2015) report some specific aspects perceived as unfeasible, including the idea that cultured meat could never be made affordable, and that it could never be made without foetal bovine serum as a culture medium, so could never be truly animal-free. Quantitative data indicates that, whilst people tend to favour the view that cultured meat is feasible, overall results are far from decisive, and significant scepticism remains (Hocquette et al., 2015; Wilks & Phillips, 2017).

3.3.2 Ethical status

There is some disagreement among consumers regarding the ethical status of cultured meat. Laestadius (2015) has argued that both those in favour of and those against the technology often express the same values, but interpret the role of cultured meat relative to those values differently. For example, whilst both claim to care about animal welfare, those in favour of cultured meat claim that the technology will reduce animal suffering, whereas those opposed to it object that it will reduce the number of living animals. However, this apparent ethical indecision is not replicated in the quantitative data: both Verbeke, Sans, et al. (2015) and Wilks and Phillips (2017) report fairly strong agreement that cultured meat is ethical, especially compared to conventional meat. Other issues including the economic impacts (Laestadius & Caldwell, 2015) and the perception of unnaturalness (Verbeke, Marcu, et al., 2015) appear to underpin ethical uncertainty about other aspects of cultured meat.

3.3.3 Regulation and control

Verbeke, Marcu, et al. (2015) and O'Keefe et al. (2016) both report that consumers were anxious to ensure proper regulation around cultured meat. Whilst participants in the latter study wanted to ensure that food producers maintained quality and choice, and that consumers would know what they are eating, Verbeke, Marcu, et al. (2015) report more detailed demands, including transparency in labelling, marketing, and information provision. Laestadius and Caldwell (2015) highlight regulation as a potential tool for building public trust and acceptance.

3.4 Positive perceptions

Whilst the most common benefits of cultured meat consumers perceive are to animals and the environment, some also acknowledge potential benefits to food security and public health. O'Keefe et al. (2016) note that positivity towards science and progress generally underlie many positive perceptions of cultured meat. This stands in opposition to the naturalistic ideology discussed above, instead holding science and technology as a source of valuable progress.

Avoiding animal slaughter was the most commonly perceived benefit of cultured meat for meat-eaters and vegetarians alike (O'Keefe et al., 2016; Tucker, 2014). Whilst some consumers have expressed concern that cultured meat will lead to a reduction in the number of living animals, reinforce demand for meat, or change our relationship to animals and nature (Laestadius & Caldwell, 2015; Verbeke, Marcu, et al., 2015), Wilks and Phillips (2017) report that on average, people agreed that cultured meat would improve animal welfare conditions, and disagreed that it would reduce the number of happy animals on earth.

Consumers also perceive benefits to the environment of cultured meat, mainly in relation to reduced greenhouse gas emissions (Bekker, Tobi, et al., 2017; Laestadius & Caldwell, 2015; Verbeke, Marcu, et al., 2015). Some express a belief that cultured meat will have environmental costs or be less efficient (Laestadius & Caldwell, 2015; Verbeke, Marcu, et al., 2015), but again the quantitative data indicates that consumers believe cultured meat will be more environmentally friendly than conventional meat, especially in terms of greenhouse gas emissions (Verbeke, Sans, et al., 2015; Wilks & Phillips, 2017).

Some studies report perceived benefits of cultured meat for public health, particularly with regards to the potential for reduced fat content (Bekker, Tobi, et al., 2017; Laestadius & Caldwell, 2015), and avoiding zoonotic diseases (Bekker, Tobi, et al., 2017; O'Keefe et al.,

2016). Wilks and Phillips (2017) report that their participants perceived less risk of zoonoses from cultured meat, whilst Verbeke, Sans, et al. (2015) report that their sample considered it safe overall, although they were undecided about its healthiness. Hocquette et al. (2015) also report split opinions on the healthiness of cultured meat.

Several studies report a perception that cultured meat will enable the global poor to afford meat (Laestadius, 2015; Tucker, 2014; Verbeke, Marcu, et al., 2015). Indeed, Tucker (2014) reports that 'higher capacity protein production' was the second most common reason given in support of cultured meat. This is seemingly underpinned by the assumption that cultured meat could be produced more cheaply and on a larger scale than conventional meat, which is unlikely to be the case initially. Cultured meat may have benefits for global food security, but these are more likely to be a result of reducing the food input of meat (which could otherwise be fed to humans) and mitigating some harmful effects of climate change.

4. Discussion

Research on consumer acceptance of cultured meat has found significant demographic variation in rates of acceptance and identified several common objections, perceived benefits, and areas of uncertainty. Further, identifiable sense-making strategies underlie discourses of acceptance or rejection, and attitudes and intentions are sensitive to the information available to consumers. In the following discussion, we place these findings in the context of wider literature, and consider some implications for the future of meat consumption.

4.1 Overall acceptance and demographic variation

The demographic trends we observe in acceptance of cultured meat are in line with those observed for other novel food technologies and related theory. In particular, studies on acceptance of genetically modified food (which many consumers consider conceptually similar to cultured meat (Marcu et al., 2015)) have observed higher acceptance amongst males vs. females (Moerbeek & Casimir, 2005), amongst younger vs. older people (Magnusson & Hursti, 2002), and amongst those with more education and familiarity with the technology (Huang, Qiu, Bai, & Pray, 2006).

Tucker (2014) points to theory which may underpin some of these trends; Bäckström, Pirttilä-Backman, and Tuorila (2003) have argued that women may be more reluctant with regards to novel foods based on heightened concerns about safety, whilst Nath (2011) highlights toughness and daring as components of western masculinity being reasons for increased willingness of males to embrace novel foods. Youth and education, meanwhile, are characteristics of early adopters of new technology according to Rogers' (2003) diffusion of innovation framework. Age has been shown to be negatively correlated with openness to experience (McCrae et al., 1999), suggesting that older people are more likely to stick to established habits. Meanwhile, those with more education are more likely to engage in analytic, deliberative thinking (Sinclair, 2014) and less likely to make decisions based on heuristics such as naturalness. In the context of cultured meat, this may be more likely to lead to acceptance. Finally, increased liking for more familiar objects is well documented, particularly with regards to food (Crandall, 1985; Pliner, 1982), though this has yet to be statistically demonstrated with regards to cultured meat.

Whilst there is limited peer-reviewed evidence around cultural variation in acceptance of cultured meat (Bekker, Tobi, et al., 2017), this is supported by evidence from outside of the peer-reviewed literature. Eurobarometer (2005) reported considerable differences in acceptance of cultured meat between different European countries, whilst Surveygoo (2018) found substantially higher acceptance in the USA compared to the UK. Given limited evidence on this issue and the increasing importance of addressing these issues in developing countries, further research is warranted. Additionally, though several analyses of media coverage of cultured meat have been published (Dilworth & McGregor, 2015; Goodwin & Shoulders, 2013; Hopkins, 2015), research thus far has not explored how media representations of cultured meat will impact consumer acceptance.

One issue in this literature is the inconsistency in descriptions given to participants and measures of acceptance used, which renders most separate studies effectively incomparable. This is an issue which accounts for the drastically different conclusions of Wilks and Phillips (2017) and Hocquette et al. (2015), but which also affects data on acceptance of cultured meat from outside the peer-reviewed literature (Flycatcher, 2013; Pew Research, 2014; Surveygoo, 2018). These surveys often report drastically different rates of acceptance, even for similar populations. Using standardised descriptions and questions would allow future research to be more comparable across time and cultures.

4.2 Objections

Although consumers in these studies raised a wide variety of objections to cultured meat, it seems that only a few are important drivers of behaviour. Wilks and Phillips (2017) asked why participants might be unwilling to try cultured meat, and found that these concerns were cited at dramatically different rates: 79% of their sample had concerns about the taste/appeal, whilst 24% had ethical concerns, and 20% were worried about the price. Interestingly, other concerns (including safety) accounted for no more than 4% of responses to this question, but this can likely be explained by the response formats; whilst the three most commonly cited concerns could be expressed by checking a box, ‘other’ concerns required participants to enter text, meaning that it is likely that safety concerns in particular were under-reported in this study. Indeed, The Grocer (2017) report that, amongst a UK sample, the most prominent concerns about cultured meat were about what chemicals or ingredients it contains (56%), possible long-term side effects (49%), and its unnaturalness (48%). Less important were concerns about its taste (29%) and price (23%). Taken together, these results indicate that

healthiness, safety, taste, and price are likely to be the most important consumer concerns. This view is corroborated by Lusk and Briggeman (2009, p. 184), who found that, regarding food choice, 'the values of safety, nutrition, taste, and price were among the most important to consumers…'

Grunert (2005) has characterised food safety as a 'sleeping giant': whilst it is not a concern for consumers under normal circumstances, when a risk is perceived, safety becomes the single most important consideration. Siegrist and Sütterlin (2017) demonstrate that safety concerns about cultured meat are inextricably linked to concerns relating to naturalness. This is in line with Yeung and Morris (2001), who argue that the perceived high level of scientific uncertainty underpin perceived risks from food technology. A recent systematic review identified perceived naturalness as crucial for the acceptance of food technologies across cultures (Roman, Sanchez-Siles, & Siegrist, 2017), reflecting Laestadius' (2015) observation that such concerns regarding cultured meat transcend cultures. Acknowledging Marcu et al.'s (2015) conceptualisation of naturalness as an ideology, future research might investigate how cultured meat advocates might address this concern; would reframing cultured meat as natural relative to conventional meat be effective, or should producers attempt to deconstruct the appeal to nature?

It is possible that many concerns about the safety of cultured meat will dissipate once it is available to consumers: whilst safety concerns have been recorded in the context of cultured meat as a future food, Van Wezemael, Verbeke, Kügler, de Barcellos, and Grunert (2010) found that safety was considered a precondition of beef being allowed to be sold, and consumers might therefore infer that cultured meat is safe merely by its availability. Hocquette (2016) has argued that cultured meat could entail some safety risks, whilst Bonny, Gardner, Pethick, and Hocquette (2015) have highlighted that it also brings about safety benefits including reduced pathogens and contaminants.

Objections based on anticipated taste or price are more straightforward. Unlike safety, which is considered a credence attribute that cannot be verified by experience (Font-i-Furnols & Guerrero, 2014), taste is an experiential characteristic, meaning that consumers can make their own judgements based on trying the product. Indeed, Wilks and Phillips (2017) found that, whilst relatively few people were willing to eat cultured meat regularly, most were willing to try it. This was amongst a sample for whom the primary concern was taste, indicating that consumers may be willing to verify this aspect for themselves.

513 Whilst some consumers anticipated a high price, others thought it would be cheaper; this may
514 be dependent on the extent to which it is framed as a solution for those in poor parts of the
515 world. Most said they would not be willing to pay more for cultured meat (Wilks & Phillips,
516 2017), which is in line with Slade's (2018) findings that lower price predicted higher
517 preference for cultured meat.

518 In summary, the data suggests that the objections most likely to drive rejection of cultured
519 meat in practice are safety concerns, taste, and price. Whilst taste and price can be verified
520 through experience, safety concerns are not only more difficult to address, but may be a
521 barrier willingness to try cultured meat (Verbeke, Marcu, et al., 2015). Cultured meat
522 advocates, therefore, should prioritise addressing safety concerns (and to the extent that they
523 are related, perceptions of unnaturalness (Siegrist & Sütterlin, 2017)), and secondarily,
524 concerns about taste and price.

525 ***4.3 Perceived benefits***

526 The most commonly perceived benefit of cultured meat was in terms of animal welfare.
527 Whilst many also perceived benefits for the environment and food security, relatively few
528 discussed the potential for cultured meat to have health/safety benefits to individual
529 consumers. The personal benefits, which appear to be the least obvious to consumers, are also
530 those which are likely to be those most important for motivating consumption of cultured
531 meat (Bruhn, 2007). However, whilst The Grocer (2017) addresses this question, there is
532 currently no data in the peer-reviewed literature assessing the relative value of health,
533 environmental, and animal welfare benefits, or the efficacy of persuasive messages based on
534 these.

5. Conclusion

The variation in survey findings points to the importance of framing. We hope that the issues identified in this review might form the basis of attempts to formulate a standard description and set of measures which can be used in future studies to enable more comparable and comprehensive data.

Furthermore, framing itself could be an important variable to consider in future research on this topic. Research could build on existing studies to investigate how different descriptions of cultured meat affect consumer acceptance, as well as the different names used. In particular, studies should investigate the most effective ways of addressing concerns around naturalness, given the centrality of naturalness to perceived safety and the acceptance of food technologies in general.

Moreover, the paucity of studies investigating the most important benefits to highlight to consumers is somewhat surprising, given the importance of such evidence in formulating information and marketing campaigns in the future. Current evidence suggests that, whilst consumers most readily perceive benefits to animal welfare and the environment, these issues are unlikely to be central to their buying decisions. Future research should therefore test the effect of highlighting these different benefits on consumer acceptance experimentally.

Overall, the research reviewed in this paper is geographically focused in Europe and the USA. Research investigating consumer acceptance of cultured meat elsewhere in the world, particularly China and India, is warranted, given that most of the forecast increase in demand for meat will be driven by those in developing countries. Moreover, some evidence suggests that the character of consumer acceptance in different cultures is likely to be significantly different from that observed in the west. Cross-cultural studies of consumer acceptance could be vital in informing future marketing or regulatory strategies.

It is likely that the picture of consumer acceptance of cultured meat will continue to change over the coming years as the concept nears commercialisation. Increased familiarity, increased perceived feasibility, regulation, commercial availability, media coverage, and the ability to try cultured meat are all factors which are likely to drive consumer acceptance in the future. Longitudinal studies which allow us to observe how, if at all, attitudes shift over time are likely to be vital going forward.

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